Case Report
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Application of 3D Simulation Surgery to Orthognathic Surgery of Hemimandibular Hypoplasia

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Traditionally 2D cephalometric analysis has been used for diagnosis and treatment of maxillofacial deformities. However, 2D has some limitations in diagnosis and treatment planning especially facial asymmetry cases. The most weakness of 2D is overlapping and unpredictability. Today 3D treatment tools are used by many maxillofacial surgeons. 3D treatment tools can show ungarbled facial anatomy and do virtual surgery. The aim of this report is to present usefulness of using 3D analysis and virtual orthognathic surgery for severe facial asymmetry patients.

Key Words Facial asymmetry · Hemimandibular hypoplasia · Orthognatic surgery · Three-dimensional surgery · Simulation surgery.

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Introduction

The analysis and treatment plan in the maxillofacial deformity has traditionally been based on 2-dimensional cephalometric measurement system (1). This has been used for clinicians steadily for several decades, but among the maxillofacial deformities, particularly in the case of facial asymmetry, the overlaping of anatomical structure become more severe, This makes it difficult to perform accurate analysis.

In addition, since post-operative 3dimensional changes must be predicted in 2-dimensions, postoperative anomalies may remain (2).

Recently, 3-dimensional analysis and research on the maxillofacial anomaly have become active, and many attempts have been made to overcome the disadvantages of the two-dimensional method. Among them, reconstructing the patient's maxillofacial bone using computerized tomography (CT) and using it in the analysis and treatment plan can reduce the difficulty of analyzing the patient's condition due to overlap of the anatomical structures in the maxillofacial region, It enables virtual surgery on a computer program so that it can predict the change of the patient's facial appearance after the actual operation (3, 4).

We report a case of severe facial asymmetry with hemimandibular hypoplasia undergoing early mandibular distraction osteogenesis surgery, After completion of the growth, orthognathic surgery was performed (5, 6). The purpose of this study was to evaluate the effectiveness of preoperative 3-dimensional virtual surgery in patients with severe facial asymmetry by predicting the asymmetric improvement effect by performing

3-dimensional virtual surgery before orthognathic surgery.

A Case Report

A 4Y 11M female patient visited the department of oral maxillofacial surgery with facial asymmetry and mandibular left deviation at the mouth opening, and performed preoperative examination including panoramic radiography and cephalometric radiography. On radiographic examination, distraction osteogenesis was performed with the use of extraoral mandibular ramus distractor under the diagnosis of condylar malnunion of the mandible (Fig. 1).

After 14Y and 6M, the patient was re-admitted to department of oral and maxillofacial surgery under the facial asymmetry and inconvenience feeling at mastication. CT scans were performed, and 3D virtual skulls were created using Simplant (Simplant pro, Materialize, Belgium) based on the CT DICOM file and diagnosed and analyzed for maxillofacial deformity. We analyzed the results of facial asymmetry and planned maxillomanibular simultaneous orthognathic surgery for mandibular posterior movement with a significant amount of maxillary canting correction, genioplasty, and shaving of parasymphysis (Fig. 2).

For precise surgical planning, the tooth portion of the 3D virtual skull overlapped the laser scan image to create a virtual craniofacial bone with accurate dental images. Based on the three-dimensional maxillofacial measurement analysis, we programmed the maxillary and mandibular movements in the

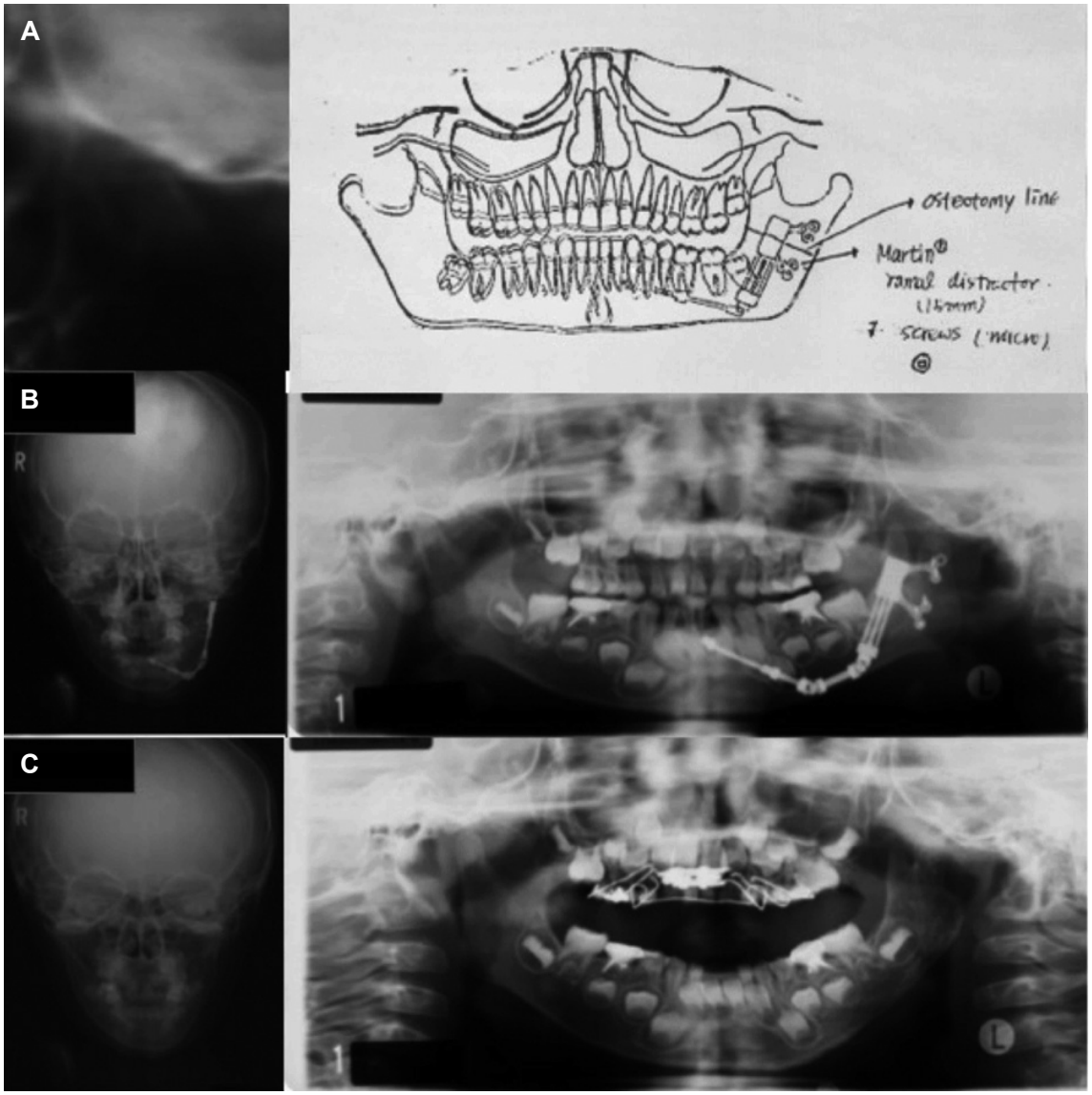

Fig. 1. 4Y 11M female with malunion condyle, Lt. (A) Malunioned condyle, Lt. (B) Illustration of operation plan (Distraction osteogenesis) (C) Before distraction osteogenesis (D) After distraction osteogenesis.

program, and based on this, the surgical plan for facial asymmetry was precisely established. Because the patient's facial asymmetry was severe, we established operation plan with canting correction of the maxilla was 8 mm or more, and lateral movement of chin top was 6 mm or more on genioplasty. Orthognathic surgery, genioplasty, and shaving of parasymphysis were performed by conventional methods, and it was confirmed that the facial and occlusal aspects were improved after surgery (Fig. 3). A virtual model was constructed from the CT images taken preoperative virtual surgery and one month after the operation, and the positions of the maxilla and mandible were compared and analyzed by superimposing them on the basis of the cranial base. It was confirmed that the maxilla and distal segment of mandible except for the operative site of shaving and the proximal segment of mandible were within the error range of 1mm or less. And the asymmetry of the face was improved much (Fig. 4).

Discussion

The conventional cephalometric images used in the analysis of the maxillofacial anomaly may cause various errors due to the representation of the complex facetted maxillofacial bone in a 2-dimensional plane. Especially, in the case of facial asymmetry, the left and right structures if you do not overlap on surface sagittal plane, the analysis may become inaccurate due to the num-

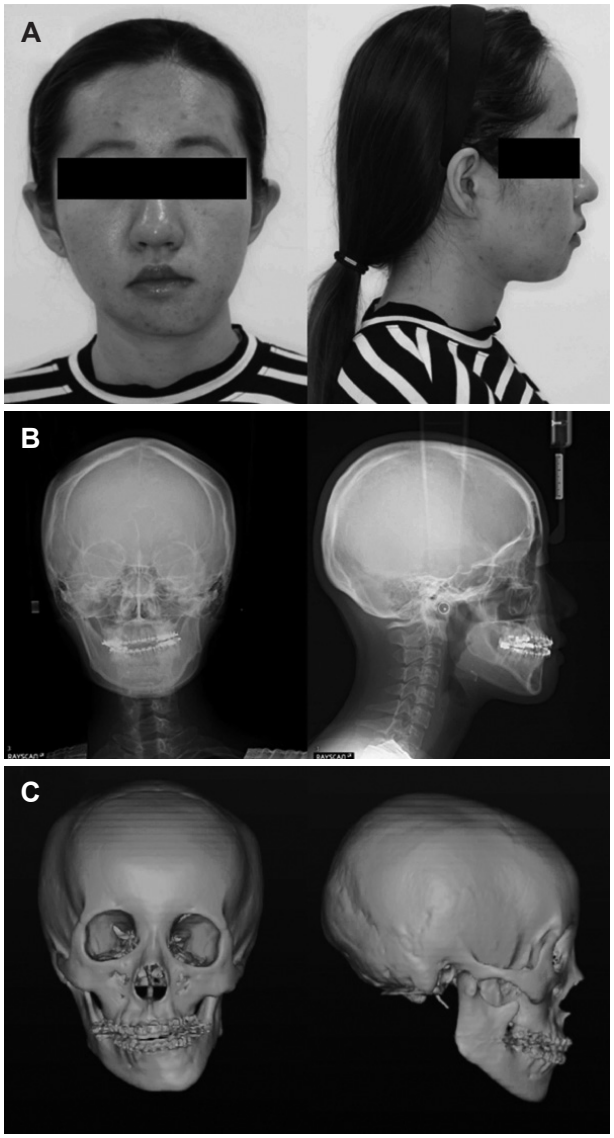

Fig. 2. 19Y 5M female with facial asymmetry before treatment (A) Facial photographs (B) Cephalometrc radiographs (C) 3D virtual skulls.

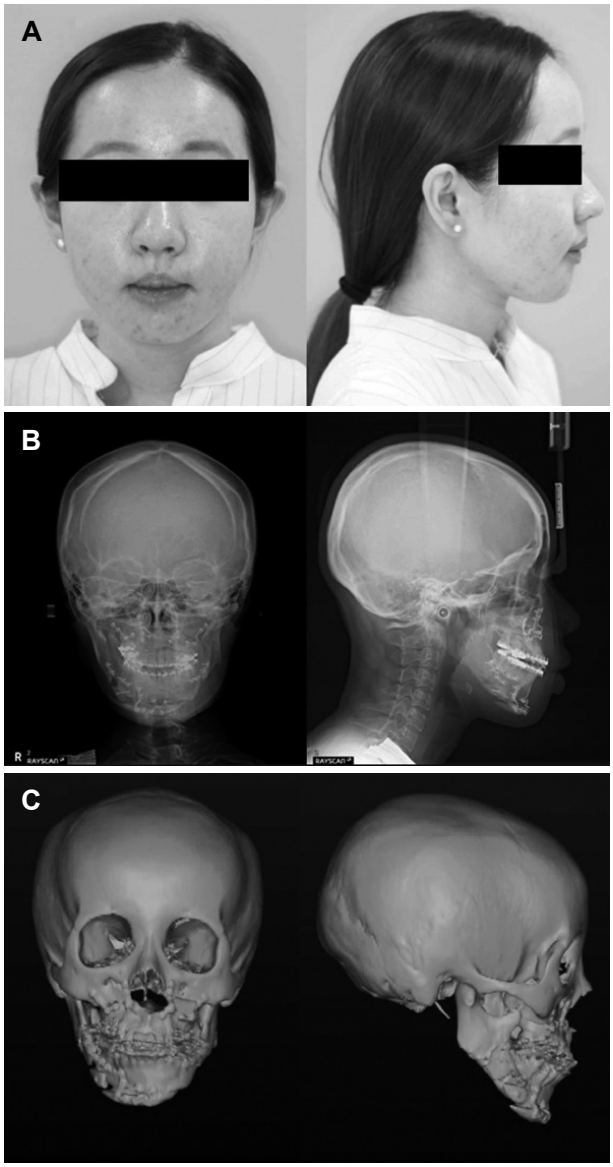

Fig. 3. After surgery facial asymmetry is corrected (A) Facial photographs (B) Cephalometrc radiographs (C) 3D virtual skulls.

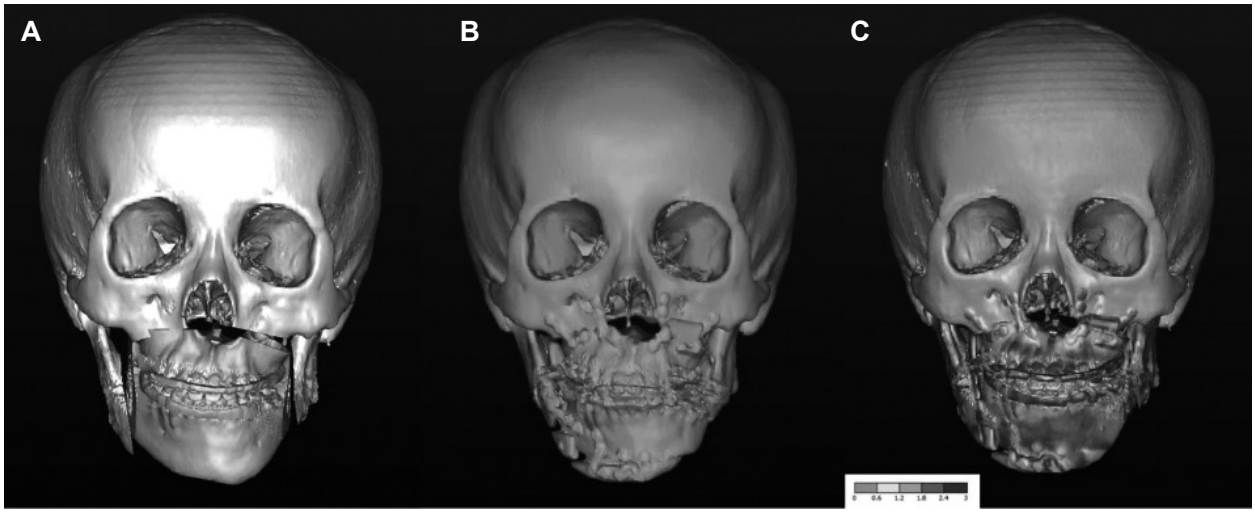

Fig. 4. Superimposition of 3D virtual skull and color scale (A) Pre-operation simulation surgery (B) Post-operation 1 M (C) Superimposition.

ber of overlapping structures (7).

Since the conventional method is to predict the 3-dimensional structure using some plane radiographs taken from the front, side and other directions, and to make the analysis and the operation plan, the change of the facial profile and the final appearance of the facial prediction is difficult.

However, comparing the three-dimensional virtual surgery with postoperative results, there was no significant difference between the various measurement sites. This is a great help in determining the exact amount of movement of the maxilla and mandible during surgery planning in cases of severe facial asymmetry that is difficult to predict with conventional methods (8).

In addition, three-dimensional images provide more intuitive images than conventional cephalometric radiographs, making it easier and quicker to plan the surgery than the two-dimensional method predicted In addition, it is easy to discuss the treatment plan with the orthodontist, and modification of the intermediate operative plan can be done simply by virtual operation, so that the surgical plan can be established more quickly and accurately than the conventional method (3).

In this case, the maxillary canting correction amount is more than 8 mm and the lateral movement amount of the chin top is more than 6 mm due to the patient's severe asymmetry. It is not easy to determine the amount of this movement by the 2-dimentional method. Therefore, in order to supplement the two-dimensional method, stereolithographic model is used, but it is also a cost problem and it is difficult to modify the model surgery. However, this discomfort was relieved through the use of a three-dimensional virtual model. As a result, it was confirmed that the error was within 1mm in the planned area including the maxillary bone and the mandibular distal segment.

In order to analyze the 3-dimensional based maxillofacial deformity, it is necessary to use the DICOM file of the CT to create the 3D virtual model, and the process such as image integration and segmentation is required , additional time, labor, and cost are considered to be required compared to the conventional analysis of 2-dimensional cephalometric analysis (10). However, in the case of severe facial asymmetry, the conventional 2-dimensional method without using 3-dimensional virtual surgery requires additional cost and time using the sialolithography model, and it is necessary to change the treatment plan before surgery, The result was unacceptable results and additional time and expense such as additional surgery. From these viewpoints, it is considered that the utility of three-dimensional virtual surgery in the case of facial asymmetry, which is particularly severe during the treatment of maxillofacial deformities, is considered to be maximized.

Conclusion

In maxillofacial deformity area, 2-dimensional cephalometric analysis method is a highly reliable method that has been used by many surgeons for a long period of time. However, facial asymmetry especially in cases of severe asymmetric diseases such as hemimandibular hypoplasia, the limit of prediction of results clearly exists and solving this was a longstanding trouble of the surgeon. Analysis of three-dimensional maxillofacial deformities and treatment planning with virtual surgery can enhance the accuracy of the surgical plan for accurate prediction of changes after asymmetric patient's surgery, while at the same time for an intuitive image it is also possible to ensure rapid operation planning. In terms of having such advantages, the utility of the operation including the three-dimensional virtual surgery seems to be very large especially from severe facial

asymmetric patients. As the future in maxillofacial deformity area research of three-dimensional analysis and virtual surgery progresses further, it may become an effective method for treating severe facial asymmetry that many operators have been suffering.

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